INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**ELECTRICAL MACHINES-I**				
Course Code	**AEEB11**				
Programme	**B.Tech**				
Semester	**III**	**EEE**			
Course Type	**Core**				
Regulation	**IARE - R18**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. K Devender Reddy, Assistant Professor				
Course Faculty	Dr. P Sridhar, Professor Mr. K Devender Reddy, Assistant Professor				

I. COURSE OVERVIEW:

This course examines the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as DC generators and motors. It also gives an in-depth knowledge on the operation of single phase and three phase transformers and it's testing. It also focus on the auto transformers, on-load, off-load tap changers which are widely used in real time applications.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS006	I	Engineering Physics	4
UG	AEE002	II	Electrical Circuits	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Electrical Machines - I	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✘	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weight age in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical and application skills of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Seminars
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignments
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Laboratory Practice

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Problem Solving:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	-	-
PSO 2	**Professional Skills:** Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	-	-
PSO 3	**Modern Tools in Electrical Engineering:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications.	2	Seminars

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the concepts of magnetic circuits and illustrate the theory of electromechanical energy conversion and the concept of co-energy
II	Understand the operation of DC machines
III	Analyze the differences in operation of different DC machine configuration
IV	Analyze single phase and three phase transformers circuits

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the basic concepts of electro-mechanical energy conversion, energy balance, energy stored in magnetic field, co-energy, single and multi excited systems.	CLO 1	Describe the basic electromagnetic energy conversion process, energy storage and energy balance.
		CLO 2	Solve simple and complex problems related to electromagnetic circuits.
		CLO 3	Derive the force and torque produced in singly excited, multi excited magnetic systems.
CO 2	Discuss the working principle, losses, efficiency, characteristics and various tests of DC generator.	CLO 4	Outline the construction, operation, windings used, concept of armature reaction, commutation and types of DC generators.
		CLO 5	Discuss the characteristics, losses, regulation, efficiency, characteristics and applications of DC generators.
		CLO 6	Examine the parallel operation of DC generators, importance of equalizer bars and load sharing
CO 3	Analyze the working principle, losses, efficiency, characteristics and various tests of DC motor.	CLO 7	Study the operation, construction, significance of back EMF, torque, characteristics and speed control methods of DC motors.
		CLO 8	Classify the different types of losses, condition for maximum power and efficiency and starters used for DC motors.
		CLO 9	Determine the efficiency of DC machines by conducting direct and indirect tests.
CO 4	Describe the working principle, EMF equation, phasor diagram, losses, efficiency, regulation, characteristics and various tests of single phase transformer.	CLO 10	Discuss the principles of operation, construction, types, EMF equation and equivalent circuit of single phase transformers.
		CLO 11	Explain the operation of single phase transformer under no-load and on-load along with its phasor diagrams.
		CLO 12	Calculate the efficiency and regulation of single phase transformers by conducting different tests.
		CLO 13	Examine the parallel operation of single phase transformers and analyze the load sharing.
CO 5	Analyze the working principle, various connections of three phase transformer. Auto transformer, Scott connection, on load and off load tap changing transformer, cooling methods.	CLO 14	Explain the operation, construction and different types of connections of three phase transformers.
		CLO 15	Demonstrate the operation of open delta connection and Scott connection with two single phase transformers and tap changing transformer.
		CLO 16	Explain the functioning of autotransformers, tap changing transformers and off-load, on-load tap changers.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEEB11.01	CLO 1	Describe the basic electromagnetic energy conversion process, energy storage and energy balance.	PO 1, PO 2	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEEB11.02	CLO 2	Solve simple and complex problems related to electromagnetic circuits.	PO 1	3
AEEB11.03	CLO 3	Derive the force and torque produced in singly excited, multi excited magnetic systems.	PO 2	3
AEEB11.04	CLO 4	Outline the construction, operation, windings used, concept of armature reaction, commutation and types of DC generators.	PO 1, PO 2	3
AEEB11.05	CLO 5	Discuss the characteristics, losses, regulation, efficiency, characteristics and applications of DC generators.	PO 1, PO 2	3
AEEB11.06	CLO 6	Examine the parallel operation of DC generators, importance of equalizer bars and load sharing	PO 1, PO 2	2
AEEB11.07	CLO 7	Study the operation, construction, significance of back EMF, torque, characteristics and speed control methods of DC motors.	PO 1, PO 4	3
AEEB11.08	CLO 8	Classify the different types of losses, condition for maximum power and efficiency and starters used for DC motors.	PO 1	2
AEEB11.09	CLO 9	Determine the efficiency of DC machines by conducting direct and indirect tests.	PO 2, PO 4	3
AEEB11.10	CLO 10	Discuss the principles of operation, construction, types, EMF equation and equivalent circuit of single phase transformers.	PO 1, PO 2	2
AEEB11.11	CLO 11	Explain the operation of single phase transformer under no-load and on-load along with its phasor diagrams.	PO 1,PO 2	2
AEEB11.12	CLO 12	Calculate the efficiency and regulation of single phase transformers by conducting different tests.	PO 2, PO 4	2
AEEB11.13	CLO 13	Examine the parallel operation of single phase transformers and analyze the load sharing.	PO 1, PO 2	3
AEEB11.14	CLO 14	Explain the operation, construction and different types of connections of three phase transformers.	PO 1, PO 2	2
AEEB11.15	CLO 15	Demonstrate the operation of open delta connection and Scott connection with two single phase transformers and tap changing transformer.	PO 2, PO 4	3
AEEB11.16	CLO 16	Explain the functioning of autotransformers, tap changing transformers and off-load, on-load tap changers.	PO 1, PO 2	2
AEEB11.17	CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations	PO4	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO3
CO 1	3	3		
CO 2	3	3		
CO 3	3	3	3	2
CO 4	2	3	3	2
CO 5	2	3	3	2

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CLOs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	2	2													
CLO 2	3														
CLO 3		3													
CLO 4	3	3													
CLO 5	3	3													
CLO 6	2	2													
CLO 7	3			3											2
CLO 8	2														
CLO 9		3		3											2
CLO 10	2	2													
CLO 11	2	2													
CLO 12		3		3											2
CLO 13	2	3													2
CLO 14	2	3													
CLO 15		3		3											2
CLO 16	2	3													
CLO 17				2											

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4, PSO3	SEE Exams	PO1, PO2, PO4, PSO3	Assignments	PO1, PO2	Seminars	PO 2
Laboratory Practices	PO3, PO4	Student Viva	PO 4	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

MODULE-I	MAGNETIC FIELDS AND MAGNETIC CIRCUITS
Review of magnetic circuits: MMF, flux, reluctance, inductance; Visualization of magnetic fields produced by a bar magnet and a current carrying coil through air and through a combination of iron and air, influence of highly permeable materials on the magnetic flux lines; Electromechanical energy conversion: Forces and torque in magnetic systems, energy balance, energy and force in a singly excited and multi excited magnetic field systems, determination of magnetic force, co- energy.	
MODULE -II	**DC GENERATORS**
DC generators: Principle of operation, construction, armature windings, lap and wave windings, simplex and multiplex windings, problems, use of laminated armature, commutator, EMF equation, types of DC generators, voltage buildup, critical field resistance and critical speed, causes for failure to self-excite and remedial measures; Armature reaction: Cross magnetization and demagnetization, ampere turns per pole, compensating winding, commutation, reactance voltage, methods of improving commutation; Characteristics: Open circuit characteristics, critical field resistance and critical speed. Load characteristics of shunt, series and compound generators; Parallel operation: Principle of parallel operation, load sharing, and use of equalizer bars, cross connection of field windings, problems.	
MODULE -III	**DC MOTORS AND TESTING**
DC motors: Principle of operation, back EMF, torque equation, condition for maximum power developed, types of DC motors, armature reaction and commutation, characteristics, methods of speed control, types of starters, numerical problems; Losses and efficiency: Types of losses, calculation of efficiency, condition for maximum efficiency. Testing of DC machines: Swinburne's test, brake test, Hopkinson's test, field's test, retardation test and separation of stray losses, problems.	
MODULE -IV	**SINGLE PHASE TRANSFORMERS**
Single phase transformers: Principle of operation, construction, types of transformers, EMF equation, concept of leakage flux and leakage reactance, operation of transformer under no load and on load, phasor diagrams, equivalent circuit, efficiency, regulation and all day efficiency; Testing of transformers: objective of testing, polarity test, measurement of resistance, OC and SC tests, back to back test, heat run test, parallel operation, problems.	
MODULE -V	**POLY PHASE TRANSFORMERS**
Three phase transformer: Principle of operation, star to star, delta to delta, star to delta, delta to star, three phase to six phase, open delta connection, Scott connection; Auto transformers: Principles of operation, equivalent circuit, merits and demerits, no load and on load tap changers, harmonic reduction in phase voltages, cooling methods of transformers problems.	
Text Books:	
1. A E Fitzgerald and C Kingsley, "Electric Machinery", New York, McGraw Hill Education, 1st Edition, 2013. 2. A E Clayton and N N Hancock, "Performance and design of DC machines", CBS Publishers, 1st Edition, 2004.	

3. M G Say, "Performance and design of AC machines", CBS Publishers, 1st Edition, 2002.
4. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 1st Edition, 2011.
5. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 1st Edition, 2010.

Reference Books:

1. M G Say, E O Taylor, "Direct Current Machines", Longman Higher Education, 1st Edition, 1985.
2. M V Deshpande, "Electrical Machines", PHI Learning Private Limited, 3rd Edition, 2011.
3. Ian McKenzie Smith, Edward Hughes, "Electrical Technology", Prentice Hall, 10th Edition, 2015.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	CLOs	Reference
1	Understand the concepts of electromechanical energy systems	CLO 1	T1: 2.1
2	Analyze the forces and torques produced in magnetic field systems	CLO 3	T1:2.4
3	Solve the different problems related to magnetic field systems	CLO 1	T1:2.4
4	Solve different analytical problems related to energy balance	CLO 2	T1:2.5
5	Understand the concept of energy and force in singly excited systems	CLO 3	T1:2.7.1 T1: 2.7.4
6	Understand the concept of energy and force in multi excited systems	CLO 3	T1:2.10
7	Solve different analytical problems related to multi excited systems	CLO 3	T1:2.10
8	Understand the concept of magnetic force and co energy	CLO3	T1:2.10
9	Understand principle of operation of DC generator	CLO 4	T1:4.1 T1: 4.2
10	Know the different parts in a DC machine and Understand the functioning of each component.	CLO 4	T1:4.3
11	Know the different types of windings used in DC generators	CLO 4	T1:4.4 T1:4.9
12	Understand why the core of a DC machine is laminated and functioning of commutator	CLO 4	T1:4.3
13	Derive the equation of EMF induced in a DC generator and solve the simple problems	CLO 4	T1:4.10
14	Distinguish the different types of DC generators and know how the voltage is buildup in DC generators	CLO 4	T1:6.1-6.2
15	Understand the concept of critical field resistance and critical speed	CLO 5	T1: 6.7 T1: 6.12
16	Understand the different causes for the failure of excitation in DC generators and know the remedies to solve the problem	CLO 5	T1: 6.13 T1: 6.14
17	Understand the concept of armature reaction in DC generator	CLO 5	T1: 5.1 T1: 5.2
18	Understand the concept of cross magnetization and demagnetization in DC generator	CLO 5	T1: 5.3
19	Solve the problems on armature reaction	CLO 5	T1: 5.7
20	Understand the concept of commutation, and know different methods used for improving the commutation	CLO 5	T1: 5.4

Lecture No	Topics to be covered	CLOs	Reference
21	Draw the different types of characteristics for DC generator	CLO 5	T1: 6.5 T1: 6.11
22	Understand the basic principle of operating the generators in parallel	CLO 6	T1: 7.1 T1: 7.4
23	Understand the function of equalizer bar and its usage	CLO 6	T1:7.2
24	Solve the different types of numerical problems related to DC generators.	CLO 6	T1: 4.1 T1: 7.4
25	Understand the basic principle of dc motor and its function	CLO 7	T1:8.2
26	Understand how the back EMF is induced in DC motor and derive the torque equation	CLO 7	T1:8.4-8.6 T1: 8.12
27	Know different types of motors and solve simple problems	CLO 7	T1:8.7.1 T1: 8.7.5
28	Understand the occurrence of armature reaction and study the commutation techniques	CLO 5	T1:8.16
29	Draw the performance characteristics of DC motors	CLO 7	T1:8.18 T1: 8.23
30	Understand the methods of speed control	CLO 7	T1: 9.1 T1: 9.3
31	Know why starters are used and different types of starters	CLO 7	T1:9.4 T1: 97
32	Understand the differ types of losses that are occurred in a DC motor.	CLO 8	T1:10.1 T1: 10.4
33	Solve different numerical problems related to efficiency of DC motor	CLO 8	T1:10.1 T1: 10.4
34	Conduct the Swinburne's test and Brake test on DC motor and compare the two methods.	CLO 9	T1:10.7
35	Conduct the regenerative test, Hopkinson's test and determine the efficiency of DC motor	CLO 9	T1:10.8
36	Conduct the field's test on DC series motor, and retardation test on DC shunt motor.	CLO 9	T1:10.9 T1: 10.10
37	Summarize the different types of losses and separate the each loss from total losses.	CLO 9	T4:10.10
38	Solve the different types of numerical problems related to DC motors testing	CLO 9	T1:8.2 T1: 10.10
39	Explain the operation, construction and types of single phase transformer.	CLO 10	T1:1.1-1.4 T1:1.24
40	Derive the equation of EMF induced in transformer and understand the concept of leakage flux and reactance.	CLO 10	T1:1.5-1.6
41	Discuss the operation of transformer under no load and on load with the phasor diagrams	CLO 11	T1:1.8-1.12
42	Draw the equivalent circuit of single phase transformer and study the concept of regulation and all day efficiency	CLO 11	T1:1.13-1.18
43	Solve the Numerical problems on EMF equation and draw the phasor diagrams	CLO 10	T1:1.1-1.18
44	Understand the objectives of testing, and kwon how to conduct polarity test and how to measure resistance.	CLO 12	T1:1.19.1 T1: 1.19.2
45	Conduct OC and SC tests on transformer and determine the efficiency and regulation at different loads.	CLO 12	T1:1.193 T1: 1.195

Lecture No	Topics to be covered	CLOs	Reference
46	Conduct back to back test / heat run test and determine the efficiency and regulation.	CLO 12	T1:1.19.6
47	Solve the problems on transformer testing	CLO 12	T1:1.19.1 T1: 1.19.6
48	Understand the necessity and importance of parallel connection of transformers.	CLO 13	T1:2.11.1 T1: 2.11.4
49	Understand how the load is shared between two transformers connected in parallel.	CLO 13	T1:2.11.1 T1: 2.11.4
50	Solve the different types of numerical problems related to single phase transformers.	CLO 13	T1:1.1-2.11
51	Understand the principle of operation of three phase transformers	CLO 14	T1:2.1-2.2
52	Analyze the different connections of three phase transformers.	CLO 14	T1:2.3.1 T1: 2.3.2
53	Solve the problems on three phase transformer connections	CLO 14	T1:2.1 T1: 2.3.2
54	Analyze how a transformer can work on open delta connection.	CLO 15	T1:2.4.1 T1: 2.4.2
55	Describe how Scott connection is performed to convert three phase supply to two phase and vice versa.	CLO 15	T1:2.5
56	Understand the principle of operation auto transformers.	CLO 16	T1:2.12
57	Draw the equivalent circuit and explain the merits and demerits of auto transformers	CLO 16	T1: 2.12.2
58	Solve the problems on Autotransformers	CLO 16	T1: 2.12.2
59	Understand the operation of no load and on load tap changers.	CLO 16	T1:1.17.1 T1: 2.17.2
60	Know how to reduce the harmonics in phase voltages	CLO 16	T1:2.62

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Effect of magnetic inrush current on the performance of transformers	MOOC courses / Laboratory Practices	PO 1, PO 2	PSO 1
2	Types of windings and section of windings in transformers	NPTEL / Industrial visits	PO 1, PO 2	PSO 1

Prepared by:

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